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TRANS-CANADA PIPE LINES LIMITED

A Discussion of Factors Relating to Transmission and Marketing of Natural Gas

FEBRUARY 1958

COMMONWEALTH SERVICES • INC.

NEW YORK, N. Y. • JACKSON, MICH. • WASHINGTON, D. C. • HOUSTON, TEX.

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TRANS-CANADA PIPE LINES LIMITED

A DISCUSSION OF FACTORS RELATING TO TRANSMISSION AND MARKETING OF NATURAL GAS

I. Competitive Factors in the Gas Industry

A. Types of Competition at the Ultimate Consumer Level.

Almost all uses of natural gas by ultimate consumers are subject to competition in varying degrees. There are a relatively few instances--for example, where gas is used as a raw material, for atmosphere control in certain industrial operations, or for certain process heating applications where close temperature control is required--where gas is chosen for technological reasons and where its price may not be the primary factor influencing its use, but it may be said in general that most uses of natural gas are subject to competitive price limits.

Where it is economically possible to price gas to the ultimate consumer on an attractive basis competitively, development of markets for gas becomes rapid. Should the prices of gas to the ultimate consumer for the various applications rise beyond the competitive level, development of markets will stagnate and should this adverse trend be accentuated, loss of market will generally ensue. It is therefore axiomatic that the policies affecting the price to the ultimate consumer must be developed carefully if the people of Canada, who as a group create the ultimate market for gas, are to achieve fully the potential benefits offered to the economy by this fine fuel with its desirable features of convenience, cleanliness, adaptability and controlability.

1. Domestic Gas Uses.

The application for which gas historically has found the widest use in the home is for cooking purposes. In terms of modern cooking appliances, the basic competitor for gas is the electric range. Although the relative cost of the two energies for cooking is a material factor, psychological factors relating to the individual purchaser also have an important bearing on the choice between gas and electricity for cooking purposes. In general, throughout a substantial portion of eastern Canada the price of electricity, mostly based on hydro generation, is relatively low. In Tabulation I, "Equivalent Cost of Alternative Fuels for Domestic Cooking and Water Heating," will be found data setting forth the incremental cost of electric cooking and the calculated equivalent cost of natural gas per Mcf for nine key communities selected to indicate conditions existing throughout the Trans-Canada Pipe Lines Limited service area. Other fuels used for cooking in Canada include liquefied petroleum gas, kerosene, coal and wood. However, with the exception of liquefied petroleum gas--where the installation is usually readily convertible to natural gas operation--the other types of cooking are not generally considered by the public as being modern and they therefore seldom offer direct competition to gas where gas is available.

Automatic water heating has become increasingly essential to the modern way of life. Where natural gas is available, it becomes a highly desirable fuel for this application in that gas water heating equipment is of relatively low cost, is rapid in its heating of the water and is fully automatic. However, where gas has been high in cost, or in areas where gas was not available, electricity has been accepted as a source of

automatic hot water service. In the development of the automatic gas water heating market the relative costs of electricity and gas as energy sources for water heating service are a more important factor than in the case of cooking, although psychological factors may also influence individual decisions in the selection of fuel sources for water heating. Tabulation I also sets forth the incremental cost of electricity for cooking and water heating combined in the nine key communities together with the calculated equivalent cost of natural gas per Mcf to render the same service. Automatic hot water service furnished in conjunction with certain types of automatic oil fired central heating equipment is another alternative source for hot water service although the basic competition at the customer level for gas for water heating is electricity.

While cooking and water heating historically have been the principal domestic applications of gas, gas refrigeration, which competes directly with electric refrigeration, has been a factor in many areas in the past and should continue to be a substantial factor in the future, although here the competition has rested more on the features of the appliance and relative cost of equipment and its installation than on the relative costs of the gas and electricity used for refrigeration. A recently developed appliance which has appeared in both gas and electric forms has been the automatic clothes drying unit. Here again, while the two sources of energy are competitive in connection with the clothes dryer, the basic choice is generally related to factors other than the cost of the gas or electricity used in the appliance.

The largest single piece of gas consuming equipment normally found in the home is related to gas space heating. This may be either in the form of the automatic gas fired central heating plant or, in the case of cold-water flats and some older single dwellings, the room-type circulating space heater. There has been a strong trend toward the installation of modern gas and oil space-heating equipment to replace hand-fired equipment using coal, coke or other solid fuels, as is demonstrated by the Dominion statistics showing the rapidly increasing number of gas and oil fired installations, set forth in Tabulation II, "Trend of Residential Heating with Gas and Oil."

For space-heating purposes, the competition for gas is principally with No. 2 fuel oil and statistics indicate that there is a general correlation between the relative prices of fuel oil and gas and the percentage of the residences to which gas is available which may be converted to gas service. Chart I, "Space-Heating Saturation Related to Differential Between Fuel Oil and Gas Prices," indicates this correlation. This chart shows the experience of a large number of gas distributing companies with respect to the space-heating saturation that they were able to achieve in competitive environments analyzed on the basis of the difference between the cost of their gas for space heating and the cost of competitive fuel oil. The heavy lines on the chart encompass 60% of the points shown and the light lines encompass 90% of them. From this chart it can be seen that even with gas selling at a premium over fuel oil on a Btu basis, a certain minimum space-heating saturation may be expected. With gas selling for space heating at the same price as fuel oil on a Btu basis, a wide range of success has been achieved with the least successful companies selling having a space-heating saturation of approximately 6% and with the most successful having a

space-heating saturation of approximately 46%. The width of the correlating band shown on the chart indicates that for a given set of price conditions there may be expected to result a space-heating saturation (percentage of homes using gas for space heating to the total homes served by the distribution company) somewhere between the high and low limits, depending in general upon the length of time natural gas has been available in a given area and the amount and type of promotional work done by the gas distribution company serving the area. Studies made by others have indicated that virtually no correlation exists between the saturation of space-heating customers and the gas-coal price relationship. This is a further indication of the desire of the householder for automatic house heating. Thus the significant figure in Tabulation III, "Equivalent Cost of Alternative Fuels for Domestic and Commercial Space Heating," is the cost of No. 2 fuel oil, although coal has been included in the tabulation for information purposes.

2. Commercial Gas Uses.

Aside from space heating, the principal use of gas for commercial purposes is in cooking and food processing operations. Here the competitive fuel is again generally electricity or No. 2 fuel oil in modern commercial installations, although the adaptability of gas in many of the cooking and food processing operations tends to weight the decision as to the fuel to be used with factors other than price alone. Although no tabulation is included, the price of commercial electricity is generally slightly higher in a given area than that for domestic purposes.

Commercial water heating is a very satisfactory application for natural gas wherein the competition is generally from automatic oil heat or from coal. The fully automatic nature of the gas equipment, its freedom from the necessity for storage of fuel on the customer's premises and its relative cleanliness and convenience are factors which together with relative price of competing fuels are important to the user's decision as to which fuel to use.

With regard to space heating, the competition is basically with No. 2 fuel oil with the same factors as outlined in the discussion of domestic space heating remaining significant for commercial heating.

3. Industrial Gas Uses:

In general, natural gas for industrial purposes falls into two broad classifications related to delivery conditions: firm and interruptible. In the case of firm gas applications, it is important to the industrial customer that the supply of gas be continuous and not subject to interruption. Firm gas may be required for technological reasons such as the need for close control, cleanliness, inert atmosphere or for small applications scattered throughout a plant, such as small heat treating furnaces or similar equipment where convenience is an important factor, or it may be required where gas is used as a raw material. Such firm gas applications in general claim a competitive price relating to the alternatives of industrial electricity, liquefied petroleum gases or high grade fuel oils (No. 1 or No. 2). It is often true for firm gas applications that the price of alternative fuels has relatively little bearing on the decision to use natural gas.

Interruptible industrial gas, however, is applicable principally in the category of boiler fuel for the firing of relatively large installations generating steam for industrial processing, power generation or general heating purposes. The alternative fuel is generally coal or relatively low-priced Bunker "C" fuel oil. For such applications, the basic question in determining the selection of fuel is the relative cost of the energy sources in terms of cents per million Btu of energy delivered to the boiler, thus price competition is virtually the sole factor in determining ability of natural gas to penetrate this market. Tabulation IV, "Equivalent Cost of Alternative Fuels for Interruptible Industrial Gas Service," indicates general price information for the key cities in the Trans-Canada Pipe Lines Limited service area, although it should be noted that often individual contracts made by major industries for large volumes of coal or oil may produce equivalent costs which are below those shown in the tabulation.

B. Price Trends of Competing Energy Sources.

In dealing above with types of competition at the ultimate consumer level, comparisons have been made as between alternative energy sources on the basis of present day comparative figures. While these are adequate for discussion of the situation at a definite period in time it is recognized that these price relationships are not static and that the future will undoubtedly bring with it changing conditions from time to time. Tabulation V, "Oil Price Trends," indicates the over-all oil price trends in eastern Canada. Similarly Tabulation VI, "Coal Price Trends," shows the coal price trends.

As regards electricity, the long-range picture has been somewhat different. Throughout the portions of Canada served by Trans-Canada Pipe Lines Limited the principal source of electric energy in the past has been the large hydro plants. As loads have increased and technology has advanced, the general trend has been toward a lowering of the retail prices for electric energy up until the post World War II period with its advent of inflation. However, now that the bulk of the economical hydro power sites located within reasonable distance of major eastern markets have been developed, the next phase of power source development, already in progress in the province of Ontario and beginning in Manitoba, will be a gradual shifting to steam generation of electricity. This is the pattern being followed by most of the major hydro power systems in the United States and may clearly be expected in Canada. The general effect of the shift to steam generation together with continuing inflation, which is more than outstripping technological improvement in the electric industry, leaves little room for expectation that the price of electricity will again resume its former downward trend; on the contrary we may expect the price trend in the future to be gradually upward.

II. Economics of Distributing Natural Gas.

A natural gas distribution system is basically a grid of underground steel or cast iron gas mains having minimum diameters of two inches or four inches in the streets in residential sections, connecting at intervals of perhaps one half mile to cross feeder mains of larger diameter, sized to supply the expected loads. Smaller diameter service lines are run from the street mains to the individual houses or buildings in connection with which shut off valves, meters and regulators, if need be, are installed on the customers' premises ahead of the point of delivery of the gas into the customer's house piping. This underground distribution system is fixed in its physical nature. Once constructed, it generally is uneconomic to remove more than the meter and regulator installation in the event a customer should discontinue his use of gas. Proper installation and protection against corrosion give virtual assurance of long life for the facilities, on the order of perhaps 30 to 50 years.

Modern techniques relating to welded steel construction, permitting smaller pipe diameters through the use of higher pressures than were common in urban manufactured gas practice, have tended somewhat to offset the effect of inflation on the investment required to install distribution systems. Nevertheless, a new modern gas distribution system may cost from $350 per customer attached to well upwards of $500 per customer as compared with investments 25 or 30 years ago on the order of $100 per customer. Because fixed annual charges relating to investment--i.e., depreciation, general taxes, insurance, return on investment and income tax associated with return on investment--are a substantial portion

of the natural gas distribution company's cost of doing business, this upward trend in distribution system investment per customer becomes an important element in determining the necessary retail price of gas to permit a distributing company to pay its expenses, including cost of gas purchased, and still earn a fair return.

In addition to the items of expense relating to investment, which we may call "Fixed Charges" and which customarily total on the order of 17% of investment, the distributing company must charge a sufficient price to cover the costs of gas it purchases from its long-distance pipeline supplier and also to cover other direct operating expenses. These direct expenses include:

1. Distribution expense--the cost of operating and maintaining the entire distribution system and also of furnishing necessary services on the customers' premises to aid the customers in utilizing the service safely and efficiently.

2. Customers' accounting expenses--the cost of reading meters, rendering bills, accounting for the company's income and disbursements and providing customer contact facilities to answer inquiries and otherwise provide satisfactory service to the customer.

3. Sales promotion expenses--promotional activities, including advertising, to encourage new customers to come on the company's lines and to increase the utilization of the service by present customers.

4. Administrative and general expenses--items such as management's salaries, legal expense and other necessary items of expense not allocable to the preceding categories.

These elements of expense, taken in total on an annual basis, are generally found to be relatable to the number of customers served by the distribution company on the average during the year and generally run from a low average of perhaps $25 per customer to upwards of $40 per customer, depending on the nature of the territory served, policies with regard to service and the state of development of the company's business. For convenience, this group of items (which does not include the major item of cost of gas purchased) may be referred to as "Other Operating Expense."

Within limits, the element of average investment per customer and hence the average annual cost element of so-called Fixed Charges is also relatable to the average number of customers served during a given year. Average annual Fixed Charges and Other Operating Expense, taken together, constitute the basic cost of distributing natural gas (excluding the purchase cost of the gas to be distributed). This basic cost of distribution is in the nature of a somewhat fixed number of dollars per customer per year and might run from say $50 for a typical existing system to a figure between $85 and $125 for a newly constructed system. Thus if the sales of gas by a distribution company having a new system with annual per customer costs of say $100 average only 40 Mcf per customer per year, the distribution company would have to charge $2.50 per Mcf over and above the cost of gas purchased if it is to cover its Fixed Charges and Other Operating Expenses.

Similarly, if the average were 200 Mcf per customer per year the distribution company would have to average 50¢ per Mcf in addition to its cost of purchased gas; or for 400 Mcf per customer per year the average amount required would drop to an average of only 25¢ per Mcf in addition to the cost of gas. The state of development of a distribution company's business thus becomes a most vital factor in the average level of retail rates required.

For comparison purposes, a typical residential customer may use 9 or 10 Mcf per year for cooking alone, 35 to 40 Mcf per year for cooking and water heating, on the high side of 40 Mcf per year for cooking, water heating and other miscellaneous uses and on the order of 180 Mcf and upwards per year for cooking, water heating, miscellaneous uses and residential space heating. The smaller-volume cooking, water heating and miscellaneous uses of gas generally produce on the average an annual load factor in the range around 70%--i.e., the average daily requirements for gas throughout the year are 70% of the requirements on the maximum day. However, space heating--the large volume residential use of natural gas--varies in its requirement with the extremes of the weather and may typically have a load factor on the order of 25% to 30%. A typical composite annual load factor for general service gas, including residential, commercial and firm industrial service, could be expected to run on the order of 40%. This means that the distribution system with these characteristics for its firm general service load must stand ready to serve on the order of 2-1/2 times as much gas to its general service customers on the coldest day in the winter as it does on the average day throughout the year. In practice, except for very small

companies, the distribution company usually is able by one means or another to improve this over-all load factor at which it purchases gas to a figure in excess of 50%.

Natural gas is customarily purchased by distribution companies from their pipeline suppliers under supply contracts which set forth the maximum daily amounts the pipeline is obligated to serve on any day in a given year and which establish rates, customarily divided into two parts between a demand charge and a commodity charge. The demand charge is an amount in dollars to be paid each month of the year, based upon the distribution company's maximum daily requirement for natural gas (usually the volume required to serve fully only the general service load on such day). Once such maximum requirement or demand is established, the demand charge continues at the same amount from month to month regardless of whether lesser volumes of gas are taken in subsequent months. The second component of the rate, the commodity charge, is based on the actual total volume of gas taken during the month and is usually expressed as a flat price per Mcf taken, although the commodity rate is sometimes expressed as a series of flat prices, stepping lower where the distribution company agrees to take an average daily amount in each month which is the higher percentage of its maximum day requirement. For example, the basic rate of Trans-Canada Pipe Lines Limited applicable in its Eastern Zone (commencing about 100 miles east of Toronto and including service to Ottawa, Montreal and many of the communities along the shore of Lake Ontario and along the St. Lawrence River) is a demand charge of $5.05 per Mcf of contract demand per month, while its commodity charges relating to different agreed minimum load factors are as follows, for the Eastern Zone:

Minimum Annual Load Factor	Commodity Charge ¢ Per Mcf
50%	32.5¢
75%	30.0¢
90%	28.0¢

There are of course various companion rates or rate features to the above, relating to firm industrial service, small customers, the development period, seasonal gas, extra interruptible gas and there are also leeway provisions in the typical supply contract. However, the above table serves to illustrate the general principle.

Applying the above Trans-Canada Eastern Zone demand-commodity rate, it will be found that the average price per Mcf purchased works out about as follows for various distribution company load factors:

Annual Load Factor	Average Rate ¢ Per Mcf
90%	46.4¢
75%	52.1¢
60%	60.1¢
50%	65.7¢
40%	82.1¢ 1/

1/ Below 50% load factor, the minimum take-or-pay-for provisions of the rate affect the average price paid for gas. If the General Service Annual Load Factor is 40% but sufficient interruptible sales can be made in addition to bring the over-all load factor up to a minimum of 50%, which is usually possible, the resulting average cost for the 40% load factor General Service gas would be reduced to 74.0¢ per Mcf, the cost for the interruptible gas would be 32.5¢ per Mcf, and the company's over-all composite cost of gas would be 65.7¢ per Mcf. For small customers up to 5,000 Mcf per day requirements, a flat rate of 67.5¢ per Mcf is provided.

It will be seen from the above that the cost of gas associated with the general service business of a distribution company, because it has a relatively low load factor, will be relatively high and consequently the distribution company must in turn charge relatively high retail rates to its general service customers to cover its expenses. However, if the distribution company can find a market for substantial sales of interruptible industrial gas--i.e., gas sales which may be curtailed or eliminated on cold days when the gas is required to meet the firm requirements of the distribution company's general service customers--it will be possible to raise the annual load factor at which the distribution company purchases its gas. While the demand charge would remain the same fixed amount each month (all chargeable to the general service customers who require all of the gas available on the maximum day) whether interruptible sales are made or not, an over-all improvement in load factor resulting from interruptible sales would reduce the effective commodity cost of all gas purchased in progressive steps, first down to 32-1/2¢ and then to 30¢ or 28¢ depending on the annual load factor which can be attained.

Moreover, such interruptible sales generally are served at high pressure from short feeder lines resulting in a relatively low additional investment to attach the business and with a relatively low item for incremental Other Operating Expense in relation to the volume of the sale. Thus if (1) the interruptible industrial load can be attached at a low incremental investment and (2) if the distribution company can sell this gas in competition with other bulk fuels at a comfortable margin above the commodity cost of the gas required for the sale itself, the spread between the

commodity charge and the sale price will contribute (after covering incremental Fixed Charges and Other Operating Expenses) to the return portion of the Fixed Charges of the distribution company as a whole. Thus, for a given rate of return, profitably attached interruptible sales have the effect of lightening the Fixed Charge burden on the general service customers. A typical example where a distribution company, through making substantial large volume interruptible industrial sales, is able to maintain an annual load factor of 90% instead of the 40% annual load factor which is assumed to result from general service sales alone, may permit establishment of lower rates to the general service customers by a margin of the order of 10%.

It should be noted in passing that the pipeline rates of Trans-Canada set forth above are based upon the assumption of a high annual operating load factor for the pipeline as a whole and would have to be materially increased should the distribution companies and the pipeline be able to sell gas only for low load factor general service purposes, with resulting poor load factor operation of the pipeline.

An alternative method by which modest improvement may be made in distribution company load factor in cases where it is not possible to make enough large volume interruptible industrial sales, is the manufacture of a portion of the company's gas requirements on the maximum days. This practice, known as "peak shaving," will not usually permit the economical establishment of as high over-all annual load factors as can be accomplished with interruptible industrial sales, where such sales are available to the

distribution company in sufficient quantity, but over-all annual load factors in the range of 50% to 75% should be readily attainable by peak shaving under almost any actual load conditions.

III. Economics of Long Distance Transmission of Natural Gas

In its simplest form, a long distance natural gas transmission system consists of a large diameter buried steel pipeline capable of operating at high pressure, with compressor stations spaced at intervals along its route. When fully powered, such a transmission system will have compressor stations located at intervals of approximately 65 miles, resulting in transportation of the maximum volumes of gas through the line at minimum over-all unit transportation cost. At today's prices for labor and materials, a typical long distance pipeline will cost between $3,500 and $4,500 per inch of diameter per mile of line (and sometimes higher over difficult terrain), with compressor stations costing $350 to $400 per horsepower of installed capacity, all depending upon circumstances encountered in construction. As a result, the typical long distance transmission line carries relatively high fixed annual charges relating to invested capital--i.e., depreciation, general taxes, insurance, return on investment and income tax associated with return on investment. Personnel required for operation and maintenance of the facilities are relatively few in number and the total of operating expenses, other than cost of gas purchased, is relatively small when compared with either cost of gas purchased or so-called Fixed Charges.

Given an assumed level of labor and material costs, there are three major elements which affect the cost of transportation of gas through a long distance pipeline:

1. Distance. The cost of transportation of natural gas through fully

utilized pipeline facilities, that is, a transmission line fully powered, with optimum spacing of compressor stations and operated on a steady load at full operating pressure, is generally proportional directly to the distance the gas is transported. Based on the feasibility studies made in connection with financing of the Trans-Canada Pipe Lines Limited line, in the fifth year of operation when the maximum input to the line is 560,000 Mcf per day, the weighted average cost of transporting gas per hundred miles is 1.86¢ per Mcf. Assuming the sale of 200,000 Mcf per day in export near Emerson, Manitoba, with the total input to the line at 784,000 Mcf per day, the weighted average cost of transporting gas per hundred miles becomes an estimated 1.81¢ per Mcf.

1½% return

In some instances, where the bulk of the load of a pipeline is concentrated near its terminus, it has been customary in the United States to treat the entire load of the line for rate making purposes as if it were carried to a single point at the line end. However, where the loads are distributed and spaced in substantial quantities over considerable distances along the line, it has become customary to recognize the factor of distance as an important element in the determination of proper costs for delivery of gas to the various loads along the line. Rates are often established by zones, each of which would include a number of delivery points from the line in the same geographical area.

2. Line Diameter. Within rather wide limits, and for a given level of labor and material costs in a particular geographical area,

it is generally true that the <u>cost</u> of a pipeline is reasonably constant if considered on the basis of cost per inch of diameter per mile of line. This linear relationship does not, however, apply to the <u>capacity</u> of a pipeline as the diameter increases. If the Panhandle flow formula is used in computations of the throughput of the line, and this is general practice for large diameter long distance pipelines, the capacity of the line will increase as the size increases, proportional to the 5/2 power of the diameter ($d^{5/2}$). Therefore, if we first consider the pipeline alone, its cost per unit of throughput tends to decrease as the diameter of the line increases. This factor has been the underlying reason for going to continually larger line diameters as pipe making technology has permitted in recent years.

The cost per installed horsepower of compressor stations remains relatively constant regardless of the horsepower installed in the station and, when the line is fully powered, the total compressor station investment is roughly proportional to the throughput of the line, so that no particular advantage is realized from larger diameter lines as to this element of investment. It is true, however, that the newer large diameter lines, because of their tremendously increased throughput capacity, have tended to offset the added cost in recent years of labor and materials, with the result that the Fixed Charges per unit of throughput for some of the new large lines are often similar in terms of cents per hundred miles transported to those for some of the older,

smaller diameter lines. However, to support a very large diameter line requires rapid development of substantial markets if the project is to be practical and is to arrive at a sound earnings basis in a reasonable period of time.

3. Annual Load Factor. The estimated fifth year average cost of 1.86¢ per Mcf per hundred miles for transportation of gas in the Trans-Canada Pipe Lines Limited line mentioned above, depends upon operating the facilities at virtually full throughput every day of the year, in other words at annual load factors of 95% or higher. It has been noted that the load factor of the general service market requirements may only be on the order of 40%, although the pipeline's rates have been established on the assumption that the pipeline itself will operate at 95% load factor or better. Chart II, "Effect of Annual Load Factor on Cost of Pipeline Transportation of Gas," shows clearly that as the load factor at which a pipeline operates is reduced, the unit cost of transportation per Mcf per hundred miles transported increases rapidly. For example, at 95% load factor operation estimated for the fifth year for the Trans-Canada line as developed in the feasibility study, the unit cost per Mcf per hundred miles transported would be 1.86¢, as above stated. Dropping the annual operating load factor to 75% would increase the unit cost of transportation to 2.33¢ and dropping to 50% annual load factor would further increase the cost of transportation to 3.46¢ per Mcf per hundred miles transported. It will thus be seen that where pipeline transportation rates have been based

on high load factor operation, such as 95%, should the cost of gas to the ultimate consumer be such that it would not be possible to attach the large volume interruptible loads necessary to maintain the high annual load factor assumed in developing the rates, and should the resulting operating annual load factor of the pipeline drop to as low as 50%, the element in the pipeline's charges to its distribution company customers for transportation would have to be approximately doubled.

There is thus a great need for balancing out the loads on a long distance pipeline to attain as high load factor operation as is feasible through the sales of substantial volumes of interruptible industrial gas at relatively low prices to meet competitive conditions, or, where such facilities are available near major markets or near the terminus of the line, through the use of underground natural gas storage, which has the effect of taking, at times when general service gas requirements are small, the remaining low-value summer "valley" gas which would normally be sold at relatively low prices for interruptible industrial purposes and converting such gas to high-value peak time winter gas available to meet firm general service requirements on the coldest days of the winter.

Competitive price levels at the market end of the pipeline thus have a substantial effect on the rates that a pipeline can charge for its gas. If the competitive price at which large volume

interruptible sales must be made is below the sum of: (1) the cost of gas at the wellhead, plus (2) the incremental cost of gathering and transmission, plus (3) some part of the Fixed Charges of the gathering and transmission system, it may then be impossible to operate the line at a high load factor. This in turn will result in the general service customer absorbing all the fixed charges, thus increasing the cost of gas to him by an amount which may approximate 100%. If the competitive cost at which natural gas may be sold for space heating is then not sufficient to cover: (1) the cost of gas at the wellhead, plus (2) the revised cost of gathering and transmission, plus (3) the cost of distribution, it will not be feasible to extend a pipeline into a particular area in question at all. Thus, the economics of transmission of natural gas depends on a satisfactory balance of types of loads and of price structures from the burner tip of the ultimate consumers through to the pipeline and back to the wellhead in the natural gas field.

It should be noted that the costs per inch mile of line today of $3,500 to $4,500 are very high compared to the figures of $2,000 to $2,500 per inch per mile which were experienced by the lines built in the United States back in the 1930s. Any line built in an earlier period at lower prices for labor and materials carries an inherent inbuilt advantage as to cost of transportation over any new line whether from Canadian or from new United States sources. This effect is partially offset where the new line can be built of very large diameter pipe and consequently for a large gas throughput. It is the interrelationship of factors of this type which result in occasional apparent

discrepancies in the relative prices of gas laid down by different pipeline systems which may be in competition for some major market.

It was noted in the discussion of distribution company economics that the rates charged to the distributor by the pipeline are customarily of two parts--a demand charge and a commodity charge. United States rate making practice currently assigns all of the cost of gas purchased in the field at a flat price to the commodity charge. Compressor fuel and similar items of out-of-pocket cost which vary with the day-to-day gas volumes transported are also assigned to commodity. Other direct operating labor and material is considered to partake of both demand and commodity elements and is assigned one half to each. Supervision and engineering expenses are assigned in the same proportion as the assignment of the expenditures supervised, whether demand or commodity, and Administrative and General expense is assigned in proportion to other expenses except purchased gas. The Fixed Charge element--depreciation, general taxes, return on investment and income taxes associated with return--is customarily split one half to demand charge and one half to commodity, on the theory that the line is not built to serve the maximum day alone (demand) but is also intended to be utilized as fully as possible every day of the year (commodity). Actual pipeline rates are usually based on such cost allocations, with the final figures tempered by the judgment of the technical rate expert designing the rates to meet the particular circumstances and problems of each individual pipeline system.

IV. Effect of Competition at the Market Level, Distribution Economics and Transmission Economics on the Price of Gas at the Wellhead

It has been noted that a rather complex pattern involving (1) competitive prices in the ultimate market, (2) distribution company economics, making desirable a high load factor purchase of gas from the pipeline supplier, and (3) long-distance transmission line economics, demanding very high load factor operation of fully-developed pipeline facilities if transportation costs are to be kept at a modest level, must all be kept in balance if the market is to grow and the distribution companies and transmission companies are to expand along with a healthy Canadian economy. Should any of the elements get out of balance with the result of pricing some major gas application out of its market, the whole structure goes out of balance. For example, a pricing requirement which would make it impossible to sell interruptible industrial gas would approximately double transportation costs, would in turn materially increase required retail prices for general service gas, and could end up with a compounding effect which would also price the general service gas itself out of its market. It has been noted further that as the average annual use of gas per distribution company customer increases, the average cost of distribution per Mcf sold declines, thus tending to improve the competitive margin protecting general service sales. Time is one of the principal ingredients in developing markets to the point where the general service use per customer becomes high and consequently the protective cushion against competition is the greatest.

The maximum supportable price for natural gas at the wellhead at any given time can be computed, although it is a complex computation, starting from the competitive prices at which the various elements in the sales mix can be sold to the ultimate consumer and deducting therefrom: (1) the cost of distribution, including a fair return on the distribution property to keep that company healthy and in a position to expand its business, (2) the cost of transportation by the pipeline supplier, including a fair rate of return on its property as well, and (3) the cost of gathering the gas from the wellhead and transporting it to the starting point of the pipeline. Over-pricing of gas at the wellhead with relation to a given pipeline and marketing system will result, first, in less than a reasonable return being earned by either the pipeline company or the distribution companies with the result that one or the other or both will have difficulty in financing the investments required for expansion to meet the requirements of growing communities. Should the pricing at the wellhead become too extreme, it can result in a situation where development of markets comes to a standstill and ultimately could result in the adverse cascade effect described earlier, should any major portion of the market be over-priced to the point where a major element of the business is lost.

An example of the operation of the foregoing principles on a favorable basis is found in the expansion plans of the Trans-Canada line. It has been noted that operation of the facilities for the fifth year as proposed in the economic feasibility study, but excluding the proposed export of gas near Emerson, with a maximum daily input of 560,000 Mcf to the pipeline, would result in a weighted average transportation cost of 1.86¢ per Mcf

per 100 miles. Addition of the sale of 200,000 Mcf per day at a high annual load factor to export near Emerson as a supplemental supply to an established market area in the United States will immediately increase the requirements of the line for input gas, including necessary compressor fuel, etc., by 224,000 Mcf per day. This will require added development of the gathering system in Alberta to take the increased volumes, additional compressor capacity along the 34 inch main line to Winnipeg and construction of a short lateral line to Emerson, but the effect on transportation cost of all sales through the 34 inch line will be a reduction estimated at 0.17¢ per Mcf per 100 miles and, for the entire transmission system, the weighted average cost per Mcf per 100 miles will be reduced to 1.81¢. The Emerson export would thus hasten the day of financial maturity for the entire Trans-Canada Pipe Lines Limited project, while at the same time benefiting the producers through attachment of a developed high load factor market capable of supporting a modest increase in field price for the additional gas because of its effect in lowering average transportation cost. The distribution company customers of Trans-Canada benefit in having a financially stronger supplier operating more efficiently and at a higher percentage of the potential ultimate capability of its pipeline and thus better able to maintain stable rate structures in the face of future inflationary forces. Stable pipeline sales rates, in turn, permit distribution companies themselves to develop their expanding markets vigorously and also to become financially strong. In addition, it is now believed that these developments may also lead to an accelerated development of the eastern Canada markets, with the result that the Trans-Canada construction program may be accelerated to reach full development of

the entire line by the fifth year of operation, in which event the input from Alberta, including the export near Emerson, might total 962,000 Mcf per day. Under such conditions, the weighted average cost of transportation would remain about the same as with the Emerson sale at 1.83¢ per Mcf per hundred miles.

V. Inherent Differences Between the Transportation of Gas and of Oil.

While gas and oil are both hydrocarbon substances and often thought of as both being in the nature of commodities, there is a basic difference in the problems of transporting and distributing oil and gas which distinguishes them as being substances of very different characteristics. After production, oil can be stored above ground at reasonable cost in tanks at the wellhead or at any point in the delivery sequence. It is capable of transportation by pipeline to central distributing points or to railhead or lakehead points or to markets and can also be transported by tank car, truck or ship. Oil may be transported from any given oil well or oil field to any selected market area and the selected market area can be changed virtually at will by substituting a different route or different means of transportation. From the market point, oil may be distributed to the ultimate consumer by railroad car, by truck or again by pipeline with a complete flexibility of delivery pattern capable of change from customer to customer or from market area to market area on little or no notice and with little or no real economic loss resulting from the change. These delivery features are characteristic not only of oil but also of all the commodity type bulk fuels such as coal and lignite.

Natural gas, on the other hand, cannot be stored above ground at a reasonable cost after production and while waiting for delivery to market. It must be produced into fixed underground pipeline facilities which extend from the gas wells dedicated to the financing of that pipeline to certain fixed distant markets. The underground investment in pipeline facilities is substantial and once the pipeline has been laid there is virtually no

flexibility which might permit it to be picked up and shifted to other markets. In the market area, natural gas is distributed in fixed underground grids which also have a high fixed investment characteristic and which also have very little flexibility. Loss of a customer by a pipeline or distribution system is a serious economic loss leaving a considerable unused investment and the shifting of markets might well prove catastrophic for gas pipeline transportation facilities.

Thus natural gas at the wellhead is more analogous to electricity at the hydro plant bus bar than it is to oil at the wellhead. Transmission is a fixed pattern for natural gas and the competition which limits the price that can be paid at the wellhead for natural gas occurs not in the gas field but at the far end of the transmission line and of the distribution system, at the ultimate consumer's burner tip.

Gas is more a service than it is a commodity. It is a way of cooking foods; a way of heating water; a way of providing refrigeration; a way of drying clothes; a way of keeping a house warm; a way of providing energy to industry.

In pricing natural gas, as has been set forth, it is necessary to work back from the competitive limits which the markets served by the pipeline will stand. The cost of distribution and the cost of transmission must be met before the amount left over which can be paid to the producer can be determined. Oil, on the other hand, is a free commodity competing in a world market.

TABULATIONS

TRANS-CANADA PIPE LINES LIMITED

EQUIVALENT COST OF ALTERNATIVE FUELS
for
DOMESTIC COOKING AND WATER HEATING

	Winnipeg	Lakehead	Kapuskasing	Toronto	London	Windsor	Niagara Falls	Ottawa	Montreal
Cost of first 90 Kwh of Electric Energy per Month for Lighting and Refrigeration	$2.07	$1.30	$2.13	$1.46	$1.84	$2.08	$1.40	$1.65	$1.89
Incremental Cost of Electric Cooking - 117 Kwh/month (equivalent to 0.8 Mcf of 1,000 Btu Natural Gas)	1.05	0.85	1.58	1.48	1.26	1.37	1.05	0.96	1.49
Calculated Equivalent Cost/Mcf of Natural Gas	1.31	1.06	1.98	1.85	1.58	1.71	1.31	1.20	1.86
Incremental Cost of Electric Cooking and Water Heating - 552 Kwh/month (equivalent to 3.19 Mcf of 1,000 Btu Natural Gas)	4.97	3.98	7.45	6.96	5.96	6.46	4.97	2.92	4.98
Calculated Equivalent Cost/Mcf of Natural Gas	1.56	1.25	2.34	2.18	1.87	2.03	1.56	0.92	1.56

Data as of December, 1957

TRANS-CANADA PIPE LINES LIMITED

TREND OF RESIDENTIAL HEATING WITH GAS AND OIL

	Newfoundland	Prince Edward Island	Nova Scotia	New Brunswick	Quebec	Ontario(2)	Manitoba	Saskatchewan	Alberta	British Columbia(1)	Total Canada
June 1951											
Number of Households using gas for heat (1,000s)	-	-	-	-	3	45	-	1	110	3	163
Number of Households using oil for heat (1,000s)	7	3	25	17	285	294	19	37	12	75	774
Total Gas and Oil	7	3	25	17	288	339	19	38	122	78	937
Total Households (1,000s)	71	22	150	114	859	1,181	202	221	251	338	3,409
% using Gas and Oil	9.9%	13.6%	16.7%	14.9%	33.5%	28.7%	9.4%	17.2%	48.6%	23.1%	27.5%
September 1954											
Number of Households using gas for heat (1,000s)	-	-	-	-	4	79	-	8	158	5	254
Number of Households using oil for heat (1,000s)	10	6	42	27	453	555	69	97	25	133	1,417
Total Gas and Oil	10	6	42	27	457	634	69	105	183	138	1,671
Total Households (1,000s)	80	24	153	118	957	1,311	224	226	282	359	3,734
% using Gas and Oil	12.5%	25.0%	27.5%	22.9%	47.8%	48.4%	30.8%	46.5%	64.9%	38.4%	44.8%
September 1955											
Number of Households using gas for heat (1,000s)	-	-	-	-	7	91	-	9	156	6	270
Number of Households using oil for Heat (1,000s)	12	6	47	30	552	653	81	108	25	142	1,656
Total Gas and Oil	12	6	47	30	559	744	81	117	181	148	1,926
Total Households (1,000s)	83	23	161	125	1,013	1,333	234	236	286	378	3,872
% using Gas and Oil	14.5%	26.1%	29.2%	24.0%	55.2%	55.8%	34.6%	49.6%	63.3%	39.2%	49.7%
September 1956											
Number of Households using gas for heat (1,000s)	-	-	-	-	6	125	1	14	174	13	333
Number of Households using oil for Heat (1,000s)	14	7	48	37	611	712	105	116	24	169	1,843
Total Gas and Oil	14	7	48	37	617	837	106	130	198	182	2,176
Total Households (1,000s)	87	24	165	128	1,045	1,370	238	236	293	388	3,974
% using Gas and Oil	16.1%	29.2%	29.1%	28.9%	59.0%	61.1%	44.5%	55.1%	67.6%	46.9%	54.8%
May 1957											
Number of Households using gas for heat (1,000s)	-	-	-	-	8	130	1	17	175	23	354
Number of Households using oil for Heat (1,000s)	24	9	58	46	668	783	98	129	37	188	2,040
Total Gas and Oil	24	9	58	46	676	913	99	146	212	211	2,394
Total Households (1,000s)	87	24	167	131	1,067	1,410	231	243	298	397	4,055
% using Gas and Oil	27.6%	37.5%	34.7%	35.1%	63.4%	64.8%	42.9%	60.1%	71.1%	53.1%	59.0%

(1) Vancouver received Natural Gas late in 1956.

(2) Toronto received Natural Gas late in 1954 and gained 23,000 in 1957.

TRANS-CANADA PIPE LINES LIMITED

EQUIVALENT COST OF ALTERNATIVE FUELS
for
DOMESTIC AND COMMERCIAL SPACE HEATING

	Winnipeg	Lakehead	Kapuskasing	Toronto	London	Windsor	Ottawa	Montreal
Cost of #2 Fuel Oil Price in Cents per Imperial Gallon	18.4¢	19.4¢	25.8¢	18.3¢	18.3¢	18.3¢	19.4¢	18.3¢
Calculated Equivalent Cost/Mcf of 1,000 Btu Natural Gas (a)	$ 1.38	$ 1.46	$ 1.94	$ 1.37	$ 1.37	$ 1.37	$ 1.46	$ 1.37
Cost of Coal - Domestic and Small Commercial Use, Weighted Average Price/Ton				1.46				1.47
Anthracite	N. A.	$29.00	$33.00	$26.50	$28.00	$26.25	$30.00	$29.35
Bituminous	$22.13	N. A.	N. A.	17.50	N. A.	N. A.	N. A.	N. A.
Calculated Equivalent Cost/Mcf of 1,000 Btu Natural Gas (b)								
Anthracite	N. A.	$ 1.65	$ 1.88	$ 1.51	$ 1.59	$ 1.49	$ 1.70	$ 1.67
Bituminous	79.0¢	N. A.	N. A.	62.0¢	N. A.	N. A.	N. A.	N. A.

(a) Oil efficiency = 60%, Gas efficiency 75%.
(b) Coal efficiency = 50%, Gas efficiency 75%.

Data as of December, 1957

TRANS-CANADA PIPE LINES LIMITED

EQUIVALENT COST OF ALTERNATIVE FUELS for INTERRUPTIBLE INDUSTRIAL SERVICE

	Winnipeg	Lakehead	Kapuskasing	Toronto	London	Montreal
Posted Price of Bunker "C" Oil in Cents per Imperial Gallon	7.2¢	8.5¢	N. A.	10.9¢	10.8¢	10.1¢
Calculated Equivalent Cost/Mcf of 1,000 Btu Natural Gas (a)	39.0¢	46.0¢	N. A	59.0¢	59.0¢	55.0¢
Price of #2 Oil in Cents per Imperial Gallon	N. A.	N. A.	21.6¢	14.0¢	18.4¢	14.8¢
Calculated Equivalent Cost/Mcf of 1,000 Btu Natural Gas (b)	N. A.	N. A.	$ 1 62	$ 1.05	$ 1.38	$ 1.11
Cost of Coal - Average Cost per Ton						
Lignite (c)	$ 6.43	N. A.	-	-	-	-
Bituminous Coal (c)	17.13	12.90	N. A	$11 97	$13.50	$12.81
Calculated Equivalent Cost/Mcf of 1,000 Btu Natural Gas						
Lignite (d)	48.0¢	N. A.	-	-	-	-
Bituminous Coal (a)	61.0¢	46.0¢	N. A.	43.0¢	48.0¢	46.0¢

(a) At assumed equal efficiencies.
(b) Oil efficiency = 60%, gas efficiency = 75%.
(c) Includes $1.00/Ton handling charges.
(d) Lignite efficiency = 75%, gas efficiency = 80%.

Oil - in Tank Car Lots.
Coal - in Carload Lots.

Data as of December 1957

TRANS-CANADA PIPE LINES LIMITED

OIL PRICE TRENDS

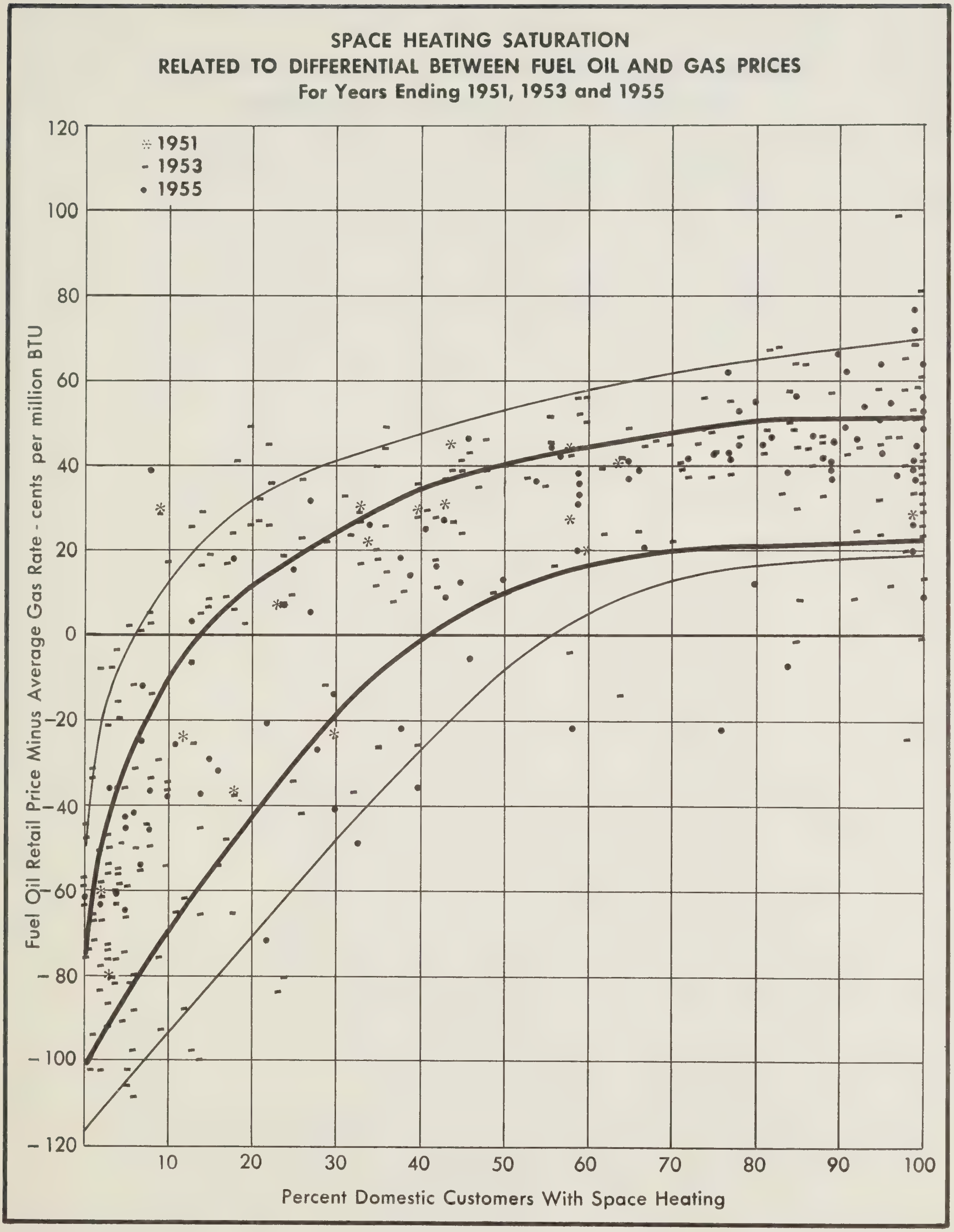
	Winnipeg	Toronto	Montreal
BUNKER "C" OIL Tank Car Lots ¢ per Imperial Gallon			
December 1947	8.4¢	10.0¢	9.3¢
December 1955	6.5¢	10.0¢	8.7¢
December 1956	7.0¢	10.5¢	10.3¢
December 1957	7.2¢	10.9¢	10.1¢
LIGHT INDUSTRIAL OIL Tank Car Lots ¢ per Imperial Gallon			
December 1947	N. A.	12.5¢	12.2¢
December 1955	N. A.	14.3¢	14.3¢
December 1956	N. A.	13.8¢	14.8¢
December 1957	N. A.	14.0¢	14.8¢
#2 FUEL OIL Tank Wagon Lots Average Retail Price ¢ per Imperial Gallon			
December 1947	16.7¢	15.0¢	13.0¢
December 1955	17.7¢	18.9¢	18.7¢
December 1956	17.7¢	19.4¢	19.2¢
December 1957	18.4¢	19.4¢	18.3¢

TRANS-CANADA PIPE LINES LIMITED

COAL PRICE TRENDS

	Toronto	Montreal
U. S. BITUMINOUS COAL Carload Price per Ton		
December 1947	$ 9.00	$10.00
December 1955	9.84	10.69
December 1956	10.52	11.37
December 1957	10.97	11.81
U. S. ANTHRACITE COAL Average Residential Price per Ton		
December 1947	$19.20	$21.00
December 1955	26.50	26.42
December 1956	30.00	27.56
December 1957	30.00	29.35

CHARTS


SPACE HEATING SATURATION
RELATED TO DIFFERENTIAL BETWEEN FUEL OIL AND GAS PRICES
For Years Ending 1951, 1953 and 1955
* 1951
- 1953
• 1955
Fuel Oil Retail Price Minus Average Gas Rate - cents per million BTU
120
100
80
60
40
20
0
−20
−40
−60
−80
−100
−120
10
20
30
40
50
60
70
80
90
100
Percent Domestic Customers With Space Heating

EFFECT OF ANNUAL LOAD FACTOR ON COST OF PIPELINE TRANSPORTATION OF GAS